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SOME RESULTS DERIVED FROM THE STUDY OF THE DEFORMATION OF ARTIFICIAL CLOUDS OF ALKALI METALS

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By J. E. Blamont and J. M. Baguette

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SOME RESULTS DERIVED FROM THE STUDY OF THE DEFORMATION OF ARTIFICIAL CLOUDS OF ALKALI METALS

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[Following is the translation of an article by J Blamont and J. Baguette in Comptes rendus des seances de l'Academie des Sciences (Reports Presented at the Sessions of the Academy of Sciences), Vol 252, Paris, 15 May 1961, pages 3099-3101.]

We have studied, as a function of time, the form of six artificial clouds of alkali metals launched at Hammaguir (Algeria) by means of Veronica rockets. The table below summarizes their characteristics.

No	Date	Hour	Altitude of apogee	Composition
1	10 March 1959	Evening	124 km	4 kg Na
2	12 March 1959	Morning	174	4 kg Na
3	2 March 1960	Evening	188	1 kg K 0.28 kg Na
4	5 March 1960	Morning	187	4 kg Na
5	13 June 1960	Evening	176	1 kg K 0.28 kg Na
6	16 June 1960	Evening	180	1 kg Na 1 kg Li

The alkali metals are emitted at an angle of solar dip of $5^{\circ}, 30'$ in the evening and 12° in the morning from an altitude of 50 km to the apogee and on the descent to the ground. They are visible by optical resonance above 90 km for a period of time which may reach 44 minutes in the evening.

They are deformed partly under the action of the wind and partly because of diffusion in the atmosphere. A series of photographs of the cloud taken by the cameras K-24 (f = 17.5 cm) or OMERA (f = 20 cm) with exposures varying from one second to two minutes permits the measurement of the wind speed and the coefficient of diffusion of sodium as a function of the altitude (see J. Blamont, Comptes rendus, Vol 249, 1959, page 1248).

The complete study will be published later (Thesis of Miss J. Baguette); it appeared to us that the following particular points should be brought out:

1. Vertical distribution of the wind. The speed and direction of the wind differ from one cloud to another. However one finds that if the direction of the wind vector is chosen as abcissa and the altitude as ordinate (figure 1), similar graphs are obtained: the direction of the wind vector changes for all the clouds in the same sense between 110 and 120 km. This graph has either a simple form (clouds Nos 2, 3 and 4) or this simple form on which a second loop between 90 and 110 km has been superposed (clouds Nos 1, 5 and 6). This direction of anticyclonic rotation corresponds to the predictions of a theory of tide resonance with a period of twelve hours, and the zone where this rotation takes place corresponds to a strong vertical temperature gradiant (P. Queney, private communication), conditions at the boundaries of the resonance. The inversion of this direction of rotation above 120 km, which is observed for all the clouds, shows that this theory is insufficient.

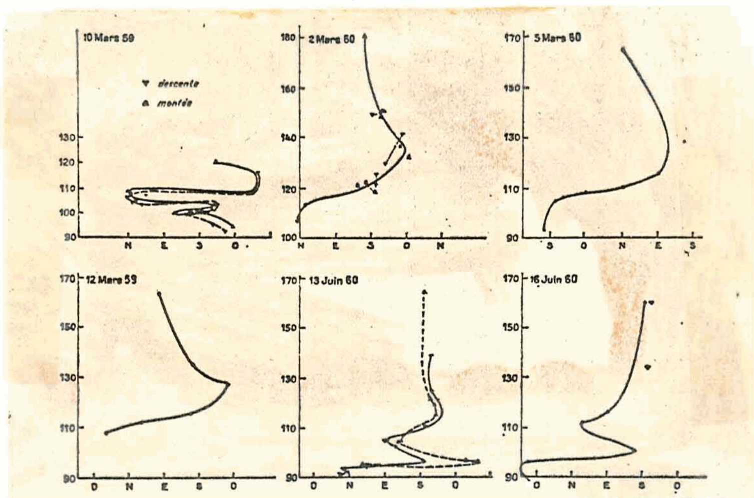

Figure 1. Direction of the wind vector as a function of altitude. (Example: E indicates a wind directed toward the East).

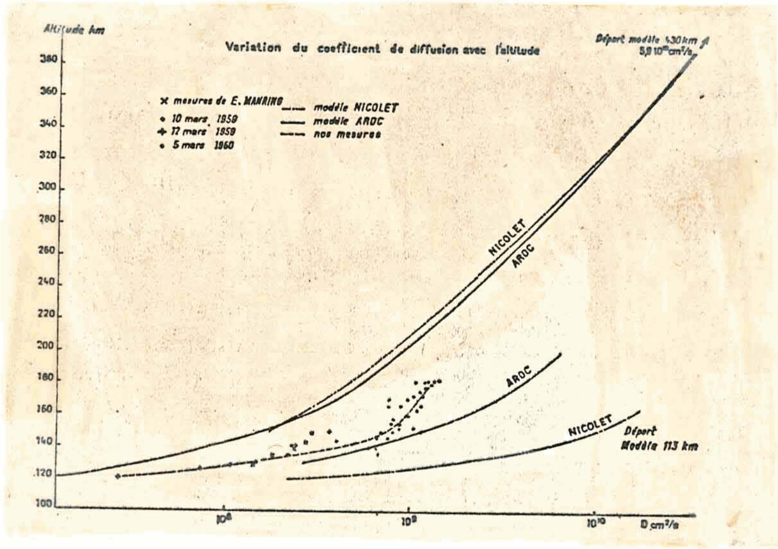

Figure 2. Variation of the coefficient of diffusion with altitude.

2. Vertical gradients. Important shearings appear between the upper limit of the zone of turbulence (see J. Blamont, Comptes rendus, Vol 249, 1959, page 1248) and 120 km. Gradients easily attain a value of 40 m/sec/km and reach up to 140 m/sec/km for cloud No 1 at an altitude of 108 km. Vertical gradients are weak outside of this region.

3. Vertical winds. The winds are essentially horizontal but we should point out the following facts:

a. Cloud No 1 presents special phenomena: at the boundary of turbulence (103 km), a plume detached itself from the sodium trail with a speed of ascent of 6 m/sec. At 105.5 km, 8 minutes after the firing, a smooth branch sheared off and the lower part turned away from the cloud.

b. The top of cloud No 4 sank at the speed of 67 m/sec; cloud No 5 showed no vertical movement above 8 m/sec; the top of cloud No 6 fell at the speed of 57 m/sec. Similar movements have been reported by Groves (see G.V. Groves, Nature, Vol 187, 1960, page 1001).

4. Diffusion. The films have a photometric guaging according to the method of Barbier (see D. Barbier, Ann. Astr., Vol 7, 1944, page 80). We have studied particularly clouds Nos 1 and 4 whose position at the zenith of the observer was very favorable. We measured the width L of the cloud as a function of time according to the method previously described (see J. Blamont, Comptes rendus, Vol 249, 1959 page 1248) and derived the coefficient of diffusion D at each altitude

from its variation. This width is difficult to define because the re-emitted intensity is not proportional to the number of atoms per cubic centimeter, as a result of the multiple diffusion of resonance light in the cloud. Since the measurements are made in a very short time interval during which the number of sodium atoms varies only slightly, we estimated that the error committed by identifying the intensity emitted with the number of atoms remains constant during the measurement and is eliminated from the result in a first approximation. The width is then defined as previously described (see J. Blamont, Comptes rendus, Vol 249, 1959, page 1248).

Figure 2 presents the results. The measurements marked (x) were obtained independently by E. Manring who kindly consented to communicate them to us before publication. The curve in points best represents our measurements. The other curves are derived, either from the model ARDC (see R.A. Minzer, A Champion and H. Pond, "ARDC Model Atmosphere," 1959, Air Force Survey in Geophysics, page 115) or from the model of Nicolet (see M. Nicolet, J. Geophys. Res., Vol 64, 1959, page 2092), by taking as the point of departure either the value of D which we measured at 113 km (see J. Blamont, Comptes rendus, Vol 249, 1959, page 1248) or the value of D measured by Schlovsky at 430 km (see I. Schlovsky and V.C. Kurt, Artificial Satellites, No 5, Academy of Sciences of the USSR, 1959, page 66). Note the very sharp variation in D in the vicinity of 150 km when approaching the anomalies in density deduced from the perturbations of satellite orbits (see W. Priester, H Martin and K. Kramp, Nature, Vol 188, 1960, page 200; H.K. Kallmann-Bijl, J. Geophys. Res., Vol 66, 1961, page 787).

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